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PHYTOPLANKTON COMPOSITION IN A BORROW PIT LAKE IN VIRGINIA

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Abstract.—The phytoplankton assemblages in Lake Trashmore, Virginia, a borrow pit, were dominated by centric diatoms and cyanobacteria, with seasonal pulses of cryptomonads, euglenoids, and chlorophyceans. Ninety species were identified and their abundance levels noted for a 12-month period.

Borrow pit lakes are generally associated with highway construction and residential landscaping. In contrast, this borrow pit lake was formed as part of an above-ground landfill operation. Alternate layers of soil and refuse were laid down to eventually form a mound that was capped with soil, then landscaped. The pit formed in this process was gradually filled with water by 1971. The lake is located in Virginia Beach, Virginia, where it is now a part of a recreational park complex. The lake has a mean depth of 4 m, a maximum depth of 7.3 m, a surface area of 21 ha, and a volume of 8.4×10^5 m^3 (Virginia State Water Control Board 1982). The surrounding area is highly developed. The lake is flanked to the north and south by major highways and is adjacent to the disposal mound (Mount Trashmore) on the west, with residential development along the eastern section.

The purpose of this study was to identify the seasonal phytoplankton composition and concentrations of this lake and to make comparisons with a phytoplankton survey of the lake made over a decade ago (Cocke 1973).

Other phytoplankton studies in Virginia have concentrated on the two natural lakes in the state, Lake Drummond and Mountain Lake (Simmons & Neff 1974, Marshall 1979). In addition, the National Eutrophication Survey (Anonymous 1972) included eight other Virginia lakes and reservoirs that were of greater size than Lake Trashmore, and all were found to be eutrophic. Phytoplankton were included in a limited water quality study during the early formation of Lake Trashmore by Beck (1973). He indicated an abundance of diatoms, chlorophyceans, cyanobacteria and phytoflagellates. Later Cocke (1973) completed a one year study of the lake and reported 45 taxa, with chlorophyceans and diatoms dominant.

In general, borrow pit lake studies are rare. In Nebraska, McCarraher et al. (1974) surveyed 41 borrow pit lakes in the Platte River Valley, with Adrian et al. (1970) conducting a primary productivity study on one lake. Seven Illinois borrow pit ponds were studied by Lipsey (1980). In all of these studies, the formation of borrow pits was associated with a major highway development. Diatoms, cyanobacteria and chlorophyceans were generally the dominant forms in these ponds or lakes.

Methods.—One collection station was established at the center and deepest (7.3 m) portion of the lake. Samples were collected monthly from the upper and lower 0.5 m of the euphotic zone from Mar 1985 to Feb 1986. The lower sampling depth was determined from transparency measurements with a Secchi disk (15 cm diam), according to Holmes (1970). A Kemmerer water bottle (2 liter) was used to obtain 500 ml water samples from both depths. These were preserved immediately with Lugol's solution and returned to the laboratory, where a settling and siphoning procedure was followed to obtain a 40 ml concentrate. Aliquots were taken from this concentrate and placed in settling chambers for examination with a Zeiss inverted plankton microscope. A random field and minimum count procedure was followed at magnifications of 312× and 500× for micro-, nano-, and picoplankton for a precision estimate of 85%. In addition, the net phytoplankton were counted by scanning the entire chamber at 125×.

Results.—Mean water temperatures ranged from 4.0°C in January to 27.3°C in August, with only small differences generally found with depth in the euphotic zone. The mean monthly pH value was 7.52, with a range from 6.5 (Dec) to 8.6 (Sep). Secchi disk readings ranged from 0.47 m (Mar) to 1.18 m (Aug), averaging 0.84 m.

Ninety phytoplankton species were identified in this study (Table 1), including 32 Chlorophyceae, 28 Bacillariophyceae, 16 Cyanobacteria, 8 Euglenophyceae, 5 Dinophyceae, and 1 Cryptophyceae. Unidentified picoplankton and nanoplankton cells were counted by size groups <3, 3–5 and 5–10 μm. They were present throughout the year, with lowest concentrations in May (3.7×10^6 cells/liter), gradually increasing to a December high (61.5×10^6 cells/liter). The majority of these cells were <3 μm in size and under epifluorescence microscopy proved to be cyanobacteria. In contrast, larger and identifiable cyanobacteria had one major pulse in summer and early fall, reaching 37.0×10^6 cells/liter in September. Euglenoids and dinoflagellates also had high summer concentrations. In contrast, the cryptomonads were in lowest concentrations in summer and early fall and became more abundant during winter and spring. The diatoms had low concentrations in spring and summer, gradually increased into fall and early winter and peaked in December (9.4×10^6 cells/liter). The dominant species were *Cyclotella* spp. and *Melosira* spp., with representatives from these genera most common in the unidentified category of centric diatoms <20 μm size.

Discussion.—In comparison to early data on phytoplankton populations in Lake Trashmore (Beck 1973, Cocke 1973), there has been a shift in composition and dominant species. Cocke identified 45 species in a seven-month study (Aug–Feb), with the two dominant groups: pennate diatoms (e.g., *Pleurosigma normanii, P. strigosum*) and chlorophyceans (*Pediastrum simplex*) the major species. He found cyanobacteria (blue-green algae) to be common, but not abundant. Other dominant species included the desmids *Closterium lunuae* and *Cosmarium circulare,* the diatoms *Fragilaria crotonensis, Melosira* spp., *Navicula* spp., and the dinoflagellate *Gymnodinium simplex.* Secchi disk readings at this time ranged between 24.0 and 54.0 cm, averaging 40.9 cm. The range of the surface pH values was 6.6 to 7.1, averaging 6.8. The present study indicated a more basic pH mean of 7.52, ranging between 6.5 and 8.6. However, the Secchi disk readings were higher, averaging 84 cm, with readings between 47 cm (Mar) and 118 cm (Aug).

In addition to an increased diversity of species, there has been a change over the past decade in the phytoplankton populations in Lake Trashmore. The transition has been from a dominance of pennate diatoms, chlorophyceans, and a filamentous-coccoid assemblage of cyanobacteria to the current status, where cyanobacteria, centric diatoms (e.g., *Cyclotella* spp., *Melosira* spp.), plus a seasonal abundance of cryptomonads, euglenoids, and chlorophyceans are dominant. It is impossible to evaluate the significance of the high picoplankton and nanoplankton (<10 μm) concentrations because Cocke's collection procedure by tow net would not have collected many of these cells. However, these changes in phytoplankton composition and abundance are assumed to be in association with the changing and advancing eutrophic state of the lake over the past decade.

Table 1.—Mean monthly abundance for each identified taxon (cells/liter).

	Mar	Apr	May	Jun
Bacillariophyceae				
Achnanthes sp.	47,268	639	5373	757
Amphora costata W. Smith	0	0	0	213
Amphora sp.	0	21	0	0
Biddulphia alternans (Bailey) Van Heurck	0	0	5	0
Cocconeis distans Gregory	21	0	0	0
Cyclotella meneghiniana Kützing	0	77,867	29,373	18,131
Cyclotella sp.	273,843	27,084	28,213	4578
C. striata (Kützing) Grunow	0	0	18,056	0
Cylindrotheca closterium (Ehrenberg) Reimann & Lewin	277	0	0	53
Cymbella sp.	9515	602	123	85
Diploneis sp.	0	0	16	12
Fragilaria sp.	0	0	0	10,579
Gomphonema sp.	0	0	16	53
Gyrosigma sp.	0	0	0	21
Melosira distans (Ehrenberg) Kützing	33,824	0	0	0
M. granulata (Ehrenberg) Ralfs	221,898	9649	299	1664
M. islandica Muller	5195	0	4557	85
M. moniliformis (Muller) Agardh	0	0	32	0
Melosira sp.	0	37	107	427
Navicula spp.	9813	37	32	117
Nitzschia clausii Hantzsch	0	0	0	64
N. pungens Grunow	43	0	0	75
N. seriata Cleve	43	0	0	0
Nitzschia sp.	14,411	16	0	32
Rhizosolenia eriensis H. L. Smith	0	0	0	0
Synedra acus Kaützing	0	0	0	0
Synedra spp.	0	21	85	587
Thalassionema nitzschioides (Grunow) Grunow & Hustedt	0	16	0	384
centrics (unid.) <20 μm diam.	285,376	293,413	178,303	81,607
centrics (unid.) 20–100 μm diam.	109,243	0	0	14,374
pennates (unid.) >20 μm in length	51,857	56,426	28,341	22,072
pennates (unid.) <20 μm in length	26,076	112	101	21
subtotal	1,088,703	465,940	294,032	156,000
Dinophyceae				
Ceratium hirundinella (O. F. Muller) Dujardin	0	0	368	19,040
Glenodinium gymnodinium Penard	0	0	0	43
Glenodinium sp.	0	3	0	0
Gymnodinium sp.	0	0	0	36,113
Protoperidinium sp.	0	0	0	96
subtotal	0	3	368	55,292
Cyanobacteria				
Anabaena sp.	725	23,138	0	576
Chroococcus limnecticus Lemmerman	0	0	0	477,533
Dactylococcopsis raphidiodes Hansgirg	2,607,829	920,865	478,484	101,230
Gomphosphaeria aponina Kutzing	120,610	152	2294	9028
Johannesbaptistia pellucida (Dickie) Taylor & Drouet	0	0	0	0
Lyngbya controta Lemmermann	0	0	0	0

Table 1.—Continued.

Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1984	0	0	0	0	256	0	0
469	64	107	0	0	0	0	64
0	0	0	0	0	247	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
18,057	18,078	36,113	0	36,455	180,907	55,297	483,016
9028	135,532	270,850	81,255	81,255	424,328	40,626	731,316
0	0	22,571	0	0	0	0	40,628
0	32,154	46,187	0	128	213	208	725
43	64	277	128	128	640	32	139
43	0	0	0	0	0	0	0
533	853	36,849	0	341	768	0	0
0	64	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	36,415	1,363,278	3,403,654	137,677	153,780
28,557	31,864	248,919	768,108	806,756	3,710,612	343,064	690,668
320	1472	427	198,623	0	0	0	0
0	0	0	0	0	0	0	0
9220	0	0	40	0	0	0	0
768	939	2965	1493	256	1963	64	18,099
9114	4557	0	0	0	256	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
128	0	555	0	0	0	0	0
0	117,432	63,198	0	0	0	0	0
43	875	53,675	128	469	700	517	789
597	51,789	124,323	49,878	3029	3212	171	299
299	18,505	272,215	0	0	180,799	0	0
117,368	153,482	329,534	135,425	261,864	1,426,466	279,190	1,923,035
21	21	18,227	0	213	640	38,369	31,599
22,571	9028	99,312	54,170	939	232,435	58,682	90,282
85	40,734	341	85	768	1244	8028	533
219,248	617,507	1,626,645	1,325,748	2,555,879	9,569,435	961,930	4,164,983
5589	3392	23,467	13,227	1408	537	16	0
85	1835	1771	981	0	0	0	0
213	0	1600	18,185	0	0	0	0
64	0	0	0	0	0	22,570	0
43	0	0	0	0	0	0	0
5994	5227	26,838	32,393	1408	537	22,586	0
1,173,683	9,619,689	6,238,578	1,760,525	2987	356,250	0	0
537,186	64,009	643,401	451,417	504,161	2,644,782	205,091	175,549
94,947	0	225,708	370,162	353,897	839,628	815,906	1,047,287
0	128	100,784	397,247	91,862	58,479	21,479	32,815
341	0	0	0	0	0	0	0
0	794,493	174,098	64,350	0	0	0	0

Table 1.—Continued.

	Mar	Apr	May	Jun
Merismopedia glauca (Ehrenberg) Naegeli	0	0	0	0
Merismopedia punctata Meyen	0	0	8038	18,526
Merismopedia sp.	0	0	0	0
Merismopedia tenuissima Lemmermann	0	0	0	0
Microcystis aeruginosa Kützing	408,516	2,471,603	2,059,101	2,719,878
Nostoc commune Vaucher	277	15,738	432	779
Oscillatoria limnetica Lemmermann	0	0	0	0
Oscillatoria sp.	0	32	208	4274
Spirulina laxa G. M. Smith	0	0	0	53
Spirulina subsalsa Oersted	0	0	0	32
blue green spheres (unid)	0	0	54,168	0
blue green trichomes (unid)	64	1129	6782	23,010
subtotal	3,138,021	3,432,657	2,609,507	3,354,919
Euglenophyceae				
Euglena acus Ehrenberg	0	0	0	0
Euglena sp.	0	0	0	1821
Eutreptia lanowii Steuer	2257	52,529	22,591	87,704
Eutreptia viridis Perty	85	0	5	43
Phacus longicaudus (Ehrenberg) Dujardin	0	0	0	0
Phacus curvicaudus Swirenko	0	0	0	0
Trachelomonas hispida (Perty) Stein	0	0	0	0
Trachelomonas volvocina Ehrenberg	0	0	0	76,608
subtotal	2342	52,529	22,591	182,572
Chlorophyceae				
Ankistrodesmus falcatus Beijerinck	156,672	27,655	31,316	31,445
Ankistrodesmus fractus (West & West) Brunnthaler	0	0	0	0
Chlorella sp.	9028	0	0	0
Chlorella vulgaris Beijerinck	0	0	0	4104
Cosmarium botrytis Meneghini	0	0	0	0
Crucigenia apiculata (Lemmermann) Schmidle	0	0	0	0
Crucigenia fenestrata Schmidle	92,219	0	0	18,057
Crucigenia quadrata Morren	0	0	9113	744,539
Crucigenia sp.	0	0	4514	0
Crucigenia tetrapedia (Kirchner) West & West	1,831,853	143,152	0	207,908
Dictyosphaerium pulcellum Wood	1365	309,316	143,839	2,013,046
Euastrum denticulatum (Kirchner) Gay	0	0	0	21
Franceia droescheri (Lemmermann)	0	0	0	0
Kirchneriella contorta (Schmidle) Bohlin	191,125	293,977	302,438	283,177
Lagerheimia ciliata (Lagerheim) Chodat	0	0	0	0
Lagerheimia quadriseta Lemmermann (G. M. Smith)	0	0	0	0
Micractinium pusillum Frensenius	0	0	0	0
Oedogonium sp.	0	0	421	0
Oocystis borgei Snow	114,091	129,214	105,047	250,682
Pediastrum duplex Meyen	0	0	0	0
Pediastrum simplex (Meyen) Lemmermann	36,147	421	1259	5845
Scenedesmus armatus (Chodat) G. M. Smith	363	0	0	0

Table 1.—Continued.

Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
0	115,257	0	341	0	0	0	0
0	171	2123	1024	308,329	704	0	0
0	0	0	0	288,907	0	0	0
0	0	15,924,935	5,673,395	870,724	928	18,056	0
10,251,540	7,031,505	8,564,855	9,331,530	6,593,405	4,709,592	82,145	251,908
2,902,609	6,414,631	4,441,940	5,254,490	3,891,212	2,146,677	928,350	853
0	993,117	672,611	361,133	0	0	0	0
22,912	13,756	0	18,057	0	427	32	0
0	18,675	85	0	171	0	0	0
0	9071	0	0	0	0	0	0
0	0	0	0	0	0	0	0
4514	9028	90,283	18,057	43	0	48	213
14,987,732	25,083,530	37,079,401	23,701,728	1,290,568	10,757,467	2,071,107	150,862
0	192	299	0	0	0	0	0
39,953	12,634	186,958	55,493	768	341	0	0
126,397	54,234	288,907	180,567	63,284	208,333	80	4099
0	21	0	0	0	0	0	0
0	0	1664	0	128	0	0	0
0	256	77,091	95,446	1323	0	32	0
448	832	832	46,282	118,307	2603	16,992	49,763
32,218	0	0	27,085	72,227	54,170	16,928	63,433
198,568	67,785	555,751	404,873	256,037	265,447	34,032	154,186
66,646	9600	46,780	317,562	72,133	8021	437	405
0	0	0	0	0	112,487	6485	2112
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	36,113	0	384	0	0	0
0	0	0	0	583,616	1,529,376	252,869	597
0	0	0	0	63,198	0	341	77,082
72,376	162,851	110,900	580,928	361,133	1,011,507	27,575	1280
18,057	0	0	0	0	0	0	235
341	0	144,453	306,963	184,151	1,594,264	188,460	277,399
0	0	0	0	0	0	0	0
128	9178	135,425	597	299	1024	0	0
18,057	0	0	0	384	0	0	0
18,057	0	0	4949	383,115	1,119,844	125,264	112,876
0	22,571	0	0	0	0	0	0
63,198	58,684	18,057	171	0	341	0	0
0	0	0	4779	0	0	0	0
0	171	0	0	0	0	0	0
176,053	361,389	487,701	397,247	297,935	2,058,442	164,761	171,773
0	0	0	0	0	0	0	0
10,197	10,603	63,957	88,832	153,583	55,808	599	1792
0	0	0	0	0	0	0	0

Table 1.—Continued.

	Mar	Apr	May	Jun
Scenedesmus bijugus Turpin Lager.	20,096	2343	0	37,685
Scenedesmus dimorphus (Turpin) Kutzing	0	0	0	85
Scenedesmus quadricaudus (Turpin) Brébisson	9625	40,405	27,276	196,406
Scenedesmus sp.	85	11,285	4530	18,398
Selenastrum gracile Reinsch	0	0	0	0
Staurastrum americanum (West & West) G. M. Smith	0	0	11	0
Staurastrum leptocladum var. *insigne* West & West	0	0	80	3008
Staurastrum paradoxum Meyen	0	0	11	341
Staurastrum sp.	0	37	43	117
Tetraedron minimum (Braun) Hansgirg	64	580	21	102,122
Chlorophyceans (unid.)	171	16,928	136,549	650,038
subtotal	2,462,904	975,313	766,468	4,567,024
Cryptophyceae				
Cryptomonas sp.	825,700	1,816,905	1,271,836	554,242
subtotal	825,700	1,816,905	1,271,836	554,242
Other taxa				
micro-phytoflagellates <10 μm	47,637	0	0	175,407
micro-phytoflagellates >10 μm	0	0	8215	43,810
small green spheres (<3 μm)	18,320,895	3,792,191	3,348,778	9,835,356
small green spheres (3–5 μm)	4,786,425	470,241	262,864	675,405
small green spheres (5–10 μm)	997,156	131,192	84,883	115,001
subtotal	24,152,113	4,393,624	3,704,740	10,844,979
Total	31,669,783	11,136,971	869,542	19,715,028

Literature Cited

Adrian, G. L., C. Throckmorton, & R. McDonald. 1970. A study of primary production in a Nebraska Interstate 80 lake.—Transactions of the Kansas Academy of Science 73(2):227–236.

Anonymous. 1972. Water quality criteria. A report of the Committee on Water Quality Criteria.—National Academy of Science and National Academy of Engineering. Washington, D.C., 219 pp.

Beck, W. M., Jr. 1973. Building an amphitheater and costing ramp of municipal solid waste. U.S. Environmental Protection Agency. SW-52d.of. Office of Solid Waste Programs Vol. I and II. Washington, D.C., 265 pp.

Cocke, G. R. 1973. A comparative limnological survey of a brackish water lake and freshwater lake at Mount Trashmore, Virginia Beach, Virginia. Masters Thesis. Old Dominion University, Norfolk, Virginia, 120 pp.

Holmes, R. W. 1970. The secchi disk in turbid coastal waters.—Limnology and Oceanography 15:688–694.

Lipsey, L. L. 1980. Phytoplankton of selected borrow pit ponds in northern Illinois.—Ohio Journal of Science 80(3):108–113.

Marshall, H. G. 1979. Lake Drummond: With a discussion regarding its plankton composition. Pp. 169–182 *in* P. W. Kirk, ed., The Great Dismal Swamp. University Press, Charlottesville, Virginia.

McCarraher, D. B., R. McDonald, & G. Adrian. 1974. Some hydrobiological characteristics of Interstate-80 highway lakes in Nebraska.—Transactions of the Kansas Academy of Science 77(2): 93–102.

Simmons, G. M., & S. E. Neff. 1974. Observations on limnetic carbon assimilation rates in Mountain Lake, Virginia during its thermal stratification periods.—Virginia Journal of Science 24(4):206–211.

Table 1.—Continued.

Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
388,218	173,006	439,333	507,080	257,401	15,104	299	1365
128	341	72,483	683	0	1024	0	0
193,623	55,109	218,088	361,133	3,250,202	326,042	84,234	198,623
49,656	0	0	153,482	35,455	270,847	0	0
0	0	21,662	128	0	0	0	0
0	0	0	0	0	981	0	64
555	2688	1536	1621	1579	512	16	0
128	1152	1314	724	384	256	0	64
13,628	85	0	0	0	0	32	0
72,227	148,968	230,223	252,793	99,696	622,950	27,153	27,192
1,060,829	871,234	3,954,410	21,397,150	1,932,063	3,186,975	354,349	442,388
2,227,102	1,887,651	5,982,435	24,376,822	4,752,529	11,915,805	1,232,874	1,315,247
306,963	446,903	979,574	451,417	486,558	1,733,426	822,677	1,584,473
306,963	446,903	979,574	451,417	486,558	1,733,426	822,677	1,584,473
81,255	279,878	419,818	343,077	379,190	442,385	144,448	18,057
15,335	153,353	0	0	591,435	219,050	240,959	503,816
14,763,970	14,238,250	18,641,155	13,708,148	16,143,985	56,011,283	5,542,049	12,748,730
1,171,918	104,048	3,066,790	1,533,350	1,555,255	3,986,723	353,223	657,151
328,575	394,290	6,900,008	635,245	240,955	876,203	35,596	120,478
16,361,053	16,106,241	22,817,681	16,219,820	18,910,820	61,535,644	6,316,275	14,048,232
34,306,660	44,214,844	69,068,298	66,512,801	39,870,929	95,777,761	11,461,481	22,775,746

Virginia State Water Control Board. 1982. Classification and Priority Listing of Virginia Lakes. U.S. Environmental Protection Agency. S-003219-010. Richmond, Virginia, 727 pp.

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